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Analyzing Price Volatility and Supply Response of Duck Eggs in the Philippines for Industry Development Implications Relative to Climate Change Adaptation

*Raquel M. Balanay**

Agricultural Sciences Department, Caraga State University, Butuan City, Philippines

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ABSTRACT

Relative to duck's importance in the discourse of sustainable agriculture as adaptation strategy for climate change, this study analyzes with ARCH and ARDL the prices and supply behavior of duck eggs in the Philippines, respectively. The price variance estimates through ARCH gives the level of price risk that duck egg producers face in the duck industry, while the inclusion of the expected prices and price variance in the supply response model provides the response of duck egg supply to price expectation and risk. Results indicate short-term time-varying price volatility in the duck egg market of the Philippines, signifying the presence of price risk. However, the price risk, although significant, is not strong enough to affect the production of duck eggs in the Philippines. Since the duck industry in the country is less explored and seems to have a diminishing size over the years, there is a need to look into market coordination, production stock improvement and food product development and innovation to harness its potentials. Policies are recommended to give special attention to such aspects to develop the said industry in support to sustainable conservation agriculture in the Philippines.

Keywords: ARCH, ARDL, conservation farming, Price volatility, supply response

1 Introduction

Duck is second to chicken in popularity in the Philippines. As valued by USDA, the growth of duck production is 1.82% compared to that of chicken, which is 7.38% in 2012. In

* Corresponding Author

Email: raquelbalanay@gmail.com

egg production, duck has increased by 1.18% against 6.92% for chicken (USDA Agricultural Marketing Service, 2012). In the past, Chang et al. (2003) had reported the same about the Philippine duck industry - to be small compared to chicken. But it is with the “unique and special role of ducks in the Philippine culture” that duck is given importance in her research. As reported by Chang et al. (2003) and Chang and Dagaas (2004), the country is using duck more for the processing of its egg than for the consumption of its meat; the latter being common in Western countries such as Australia, USA, Canada and France, and in Asian countries such as China, Taiwan and Singapore. “About 90% of total egg production is used for processing (BAS-SRTC, 1998 as cited by Chang and Dagaas, 2004),” in which “87% is made into balut or embryonated egg by the Chinese and hot vitlon by the Vietnamese, while the other 7% and 6% are processed into salted eggs and century eggs, penoy and other unidentified forms, respectively. Balut is a Filipino term for a “partially incubated duck eggs whose live embryos are harvested between 16-18 days old” (Chang and Dagaas, 2004).

However, concerns on duck industry are not only put together in view of its current economic status, but in view of its vast potentials in stabilizing the poultry industry amidst the issues of climate change. The Philippines is currently in the position of trying to withstand the effects of climate change, which includes prolonged rain incidence, increasing rainfall amount, and increasing frequency of strong typhoons, not to mention the disasters they create such as floods and landslides. Even if not a leading poultry producer in the Philippines, duck is however regarded as a sturdier poultry animal compared to chicken that is the current leading poultry producer, especially under climate change scenario. According to Holderread (2011), “ducks are incredibly resistant to disease and cold and wet weather.” Besides that, he had reported ducks to be more proficient layers than chickens and their eggs to retain freshness during storage considerably longer than those of chickens. According to CARE Canada (as cited in OECD, 2009, p. 135), as a strategy of coping with the growing risk of floods, women in Bangladesh have been aided in raising more ducks than chickens for household consumption and income generation purposes.

Owing to the dominance of duck egg and *balut* production in the Philippine duck industry, the quantitative evaluation of this study is focused on it for consequent policy implications relative to the strengthening of the said industry. The use of ARCH on this aspect is due to the purpose of finding unpredictable movement in the price series of duck eggs and the supply response of which to any unpredictable price changes including the possibility of forming price expectations among the duck egg producers, which is important for long-term planning for enterprise development purposes. The analysis is aggregated at country level basis to determine the overall status of the duck egg industry in the Philippines over a 20-year period where the country has been bracing for the effects of climate change to many of its economic sectors. This is for the objective of strengthening the duck industry in support to developing the adaptive capacity and stabilization of the poultry industry in the country, which is among the significant sources of nutritional protein among the Filipinos.

2 Data and Econometric Approach

The data used for the analysis were mostly obtained from the Bureau of Agricultural Statistics through its online information service at Countrystat website. These data pertained to the series of price and supply levels of duck eggs for the estimation of the commodity's own price volatility and supply response from 1990-2009. Time series data about the prices of pork, beef, yellow corn and crude oil were also obtained to constitute the other factors considered in supply response estimation. Consumer price indices from 1990-2009 (CPI) from the National Statistical and Coordination Board (NSCB) were used to deflate the various price series of the commodities. On the other hand, the crude oil prices for the period 1990-2009 were obtained from the Oil Management Bureau (OMB) of the Department of Energy (DOE) at Taguig City, Metro Manila.

Primarily, autoregressive conditional heteroscedastic (ARCH) approach was used to estimate the price volatility of duck eggs in the Philippines. The ARCH process is used to generate the expected price, P_t and the expected price variance, h_t , which would become part of the explanatory variables in the supply response model for duck eggs. The ARCH model is specified as follows:

$$P_t|\Omega_{t-1} = c_0 + \sum_{i=1}^n c_i P_{t-i} + \epsilon_{2t} \quad (1)$$

$$h_t = b_0 + \sum_{i=1}^q b_{1i} \epsilon_{2t-i}^2 + \sum_{i=1}^p b_{2i} h_{t-i} \quad (2)$$

$$\epsilon_{2t}|\Omega_{t-1} \sim N(0, h_t)$$

where $b_0 > 0$, $b_{1i} \geq 0$, $i = 1, \dots, q$, $b_{2i} \geq 0$, $i = 1, \dots, p$, $\sum b_{1i} + \sum b_{2i} < 1$

According to Rezaee and Stavropoulos (2009), the ARCH (Engle, 1982) makes the “conditional variance h_t to depend on past volatility measured as a linear function of past errors, ϵ_{2t} while leaving unconditional variance constant”. In Equation 1, ϵ_{2t} is a discrete time stochastic error, and Ω_{t-1} is the information set of all past states up to the time $t-1$. In Equation 2 (GARCH conditional variance equation), h_t is the conditional variance specified as a linear function of p lagged squared residuals and its own q lagged conditional variances. The variance is expected to be positive, and so are the coefficients b_0 , b_{1i} and b_{2i} . The stationarity of the variance is preserved by the restriction $\sum b_{1i} + \sum b_{2i} < 1$ (Rezaee and Stavropoulos, 2009). The predictions of P_t^e and h_t generated by the ARCH model would be incorporated in the estimation of the supply function for duck eggs specified later.

On the other hand, the model for supply response estimation takes the context where error correction is a part. Considering a general autoregressive distributed lag or ARDL (1,1) model, $y_t = \mu + \gamma_1 y_{t-1} + \beta_0 x_t + \beta_1 x_{t-1} + \epsilon_t$ and defining the first differences $\Delta y_t = y_t - y_{t-1}$ and $\Delta x_t = x_t - x_{t-1}$, the above model can be rearranged to obtain an error correction model of $\Delta y_t = \mu + \beta_0 \Delta x_t + (\gamma_1 - 1)(y_{t-1} - \theta x_{t-1}) + \epsilon_t$ where $\theta = -(\beta_0 + \beta_1)/(\gamma_1 - 1)$. In

this form, an equilibrium relationship $\Delta y_t = \mu + \beta_0 \Delta x_t + \epsilon_t$ is attained with an equilibrium error, $(\gamma_t - 1)(y_{t-1} - \theta x_{t-1})$, which account for the deviation of the pair of variables from that equilibrium. The model states that the change in y_t from the previous period consists of the change associated with movement with x_t along the long-run equilibrium path plus a part $(\gamma_1 - 1)$ of the deviation $(y_{t-1} - \Delta x_{t-1})$ from the equilibrium. With a model in logs, this relationship would be in proportional terms (Greene, 2003).

As used in the supply response estimation of duck eggs, the error correction model describes the variation in the dependent variable, y_t , around its long-run trend in terms of a set of $I(0)$ exogenous factors x_t , the variation of the linear combination of cointegrated variables, z_t , around its long-run trend, and the error correction that is the equilibrium error in the model of cointegration. There is a tight connection between models of cointegration and models of error correction. The model in this form is reasonable as it stands, but in fact, it is only internally consistent if the two variables are cointegrated. For cointegrated variables in time series analysis, error correction is necessary because differencing would be counterproductive since it would just obscure the long-run relationships of the variables (Greene, 2003).

3 Methodology and Model Specification

For the estimation of price volatility, the deflated duck egg prices have to be tested for stationarity with Augmented Dickey-Fuller (ADF) test. The ADF test is used when the error terms of the estimating equations are correlated; in which case, sufficient number of lagged difference terms of the dependent price variable is necessary to make the error terms serially uncorrelated (Gujarati, 2004). That test would also determine the form at which the price series is stationary. Stationarizing the said series is necessary in order to avoid serious mistakes in making inferences with time series models (Greene, 2003). Then, differencing the series is followed to stationarize the data series.

The autoregressive conditional heteroscedastic-Lagrange multiplier (ARCH-LM) test is then applied to determine the presence of volatile movements in the series. The results of the ARCH-LM test basically provide the basis of using ARCH in the estimation of price volatility through the expected variance. If the results of the said test are significant, ARCH would be used in generating the expected price and price variance. Otherwise, the autoregressive integrated moving average (ARIMA) model would be applied in estimating the said expected price and price variance (Modelina et. al, 2003 as cited by Jordaan, Grove and Alemu, 2007). It is an integrated model because the stationary autoregressive moving average (ARMA) model that is fitted to the differenced data has to be summed or “integrated” to provide a model for the nonstationary data (Maddala, 1992).

The expected price and price variance generated from the use of ARCH or ARIMA are incorporated in the supply response model of duck eggs. The unadjusted form of the

supply response model is specified as:

$$QP_n = \sum_{i=1}^4 a_i D_{it} + a_{13} TR_t + PPP_t^e + PPCV_t + PSP_t + PSB_t + PCOP_t + PYC_t + QP_{t-i} + e_{1t}$$

where QP_n is the production of duck eggs in period t ; D_{it} is a quarterly dummy variable ($i = 1, 2, 3$ and 4); TR_t is a trend component; PPP_t^e is the expected real price of duck eggs in time t ; $PPCV_t$ is the expected real price variance of the said product in time t ; PSP_t is the real price of pork as a poultry meat substitute in time t , PSB_t is the real price of beef as another poultry meat substitute in time t ; $PCOP_t$ is the real price of crude oil in time t ; PYC_t is the real price of yellow corn, and QP_{t-i} is the production of a poultry product in time $t - i$ where $i = 1, \dots, 4$.

Similar to the study of Rezitis and Stavropoulos (2009), D_{it} as the quarterly dummy variable is used to capture the seasonal changes in production brought about by the seasonality in consumption (e.g. during holidays and special occasions). PPP_t^e and $PPCV_t$ are the important risk factors of the equation. PSP_t and PSB_t represent the real prices of duck egg substitutes in terms of meat - pork and beef - respectively, which affect production when there is “news” of transmittable disease outbreak among swine and cattle. The involvement of $PCOP_t$ in the model is credited to the study of Du, Yu and Hayes (2009), which has established the influence of crude oil price changes to the volatility of prices in agricultural commodities. PYC_t is the real price of yellow corn, which represents the price of feed as input to duck production. Yellow corn prices affect the price of feed; thus, it may affect duck egg supply if yellow corn prices change. The QP_{t-i} is used to capture the lags of production because production naturally needs time to adjust to a desired level (Rezitis and Stavropoulos, 2009).

With the strong possibility of cointegrated relationships among the variables in the model, Johansen test for cointegration has to be performed. If cointegration is significant in the model, the unadjusted supply response model must be transformed to reflect the first differences of the parameters plus the error correction factor. With the presence of an error correction factor, the model becomes capable of implying significant feedback mechanisms among the markets, which indicates market interdependence and linkages. In the autoregressive supply response models, the lag length is determined by the Akaike information criterion (AIC). The use of the above estimating procedure is based also on the review of the works of Aradhyula and Holt (1998 as cited by Rezitis and Stavropoulos, 2009), Rezitis and Stavropoulos (2009), Du, Yu and Hayes (2009), Bekkerman and Pelletier (2009), Jordaan, Grove and Alemu (2007) and Kilic (2006).

4 Results and Discussion

Duck production is around 10 metric tons annually and preference of it is high in Southern Luzon and in the Muslim regions of the country. By geography, duck is raised

extensively in Central Luzon (Region III), CALABARZON (Region IV-A), Davao Region (Region XI), Cagayan Valley (Region II), Western Visayas (Region VI), Ilocos Region (Region I) and SOCCSKSARGEN (Region XII). An aggregate volume of duck produced in Central Luzon and CALABARZON comprises almost 50% of the country's total volume (BAS, 2010). In terms of duck eggs, production is around 42,000 metric tons every year, which is highest in Central Luzon that produces 1/4 of the country's total volume of duck eggs. Cagayan Valley, CALABARZON, Western Visayas, Ilocos Region, SOCCSKSARGEN and the Autonomous Region of Muslim Mindanao (ARMM) are the other provinces that likewise top in the production of duck eggs in the Philippines.

Test for Stationarity of Duck Egg Prices and Other Variables in Supply Response Estimation

The results for the stationarity test of the data series for duck egg prices and other variables involved in the consequent supply response estimation is shown in Table 1. Augmented Dickey-Fuller test results show the presence of unit roots in the data series of these variables, which signify the presence of volatile movements in the series at level form (L) in particular, except for the real price of yellow corn. In level form, unit roots are noted in the real prices of duck eggs, pork (lean meat), beef (lean meat), diesel and duck egg production. All data series are stationarized only in second differencing, since the null hypothesis of non-stationarity or presence of unit roots is rejected at 5% level of significance.

Price Volatility in the Duck Egg Market

Prior to the ARCH analysis for price volatility in duck eggs, ARCH-LM test was employed to determine the presence of ARCH effects or volatile movement in the series. The result of this test yields a highly significant LM statistic equal to 19.0237 for the real price of duck eggs, which confirms the presence of such movement in the aforementioned price series. This follows that the succeeding analysis for the price of duck eggs qualifies for the use of ARCH that this study has employed accordingly with first-difference values in log form. In Table 2, the results of ARCH analysis show that short-term time-varying price volatility exists in the duck egg market of the Philippines, since the coefficient of the residual under the variance equation results is highly significant. This finding suggests a significant risk from price changes. The ARCH results show that the rates of change in the prices of duck eggs could be highly unpredictable, which could amplify the level of uncertainty in the duck egg market of the country.

Supply Response of Duck Eggs under Price Volatility

The duck egg market in the Philippines could be impervious to its price risk/uncertainty. With the insignificance of the coefficient for the expected price variance in the supply response estimation results in Table 3, the duck egg supply is found to be unaffected by

the presence of high price uncertainty in its market. The analysis for supply response was carried out with the integration of an error correction factor, which was decided upon after testing for the presence of cointegration with Johansen test. Meanwhile, the said test had yielded results indicating the presence of cointegrating movements with Trace statistics of $K \leq 6 = 2.82$ significant at 5% level of confidence. This finding means that the presence of cointegrating movements can obscure the true long-run relationships between factors or variables involved in the supply response model. To address it, the integration of an error correction factor should be done to improve the supply response estimation results. In economic meaning, the error correction factor could subsume the influence of feedback mechanisms among the variables in the supply response model on duck egg supply in the country.

The results of the error-corrected supply response estimation show further that duck egg supply in the country is affected by production timing (with the significance of production in Quarter 2 and Quarter 4), the expected real price of duck eggs, the error correction factor, and its previous supply levels. Production in Quarters 2 and 4 are both higher compared to that of Quarter 1. The expected real price of duck eggs conforms to the priori notion on price-supply relationship, which means that more eggs are produced when prices of duck eggs keep rising. However, overall production growth is declining for duck eggs, as shown by the significant but negatively-signed coefficient for lagged duck egg production. With respect to the error-correction factor, adjustment for it is justified and it means that duck egg supply responds to the feedback mechanisms in its market, where the product markets involved in the model use information from each other in forming expectations and decisions.

5 Conclusion

The duck egg industry in the Philippines is faced with significant price volatility, which could put at stake the performance of its industry due to price uncertainty. But its price volatility is noted not strong enough to pose alarm in duck egg production/supply. This could be interpreted as resiliency of the duck egg market, which could be harnessed to strengthen further the duck industry in the country. However, even with the favorable findings of the duck egg market performance, it is still recommended that its price volatility should be checked or monitored to arrest any impending threat to the duck egg market or the duck industry as a whole. This could be undertaken better with expansion of its market in mind. With that, programs that deal with studying the expansion of the market for duck eggs and other duck-based products of the country to the international level (e.g. China and others) are recommended to be undertaken to harness the potentials of the duck industry in the country.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Table 1: **ADF test results for stationarity of variables in duck egg supply, Philippines, 1990-2009.**

Variables	L	FD	SD
Real price of duck egg	-1.26	-9.64*	-10.19*
Real price of pork (lean meat)	-2.04	-5.52*	-6.01*
Real price of beef (lean meat)	-1.51	-4.10*	-7.74*
Real price of diesel (per liter)	-0.61	-5.51**	-7.79*
Real price of yellow corn grain	-3.70*	-7.83*	-8.76*
Duck egg production	-1.57	-2.36	-8.04*

* indicates rejection of the null hypothesis of non-stationarity at the 5% significance level; L-represents level form values; FD-represents first differences; SD-represents second differences

Table 2: **ARCH results for price volatility of duck eggs, Philippines, 1990-2009.**

Variables	Coefficient	Std. Error	z-Statistic
C	-0.002782	0.001722	-1.615185
D(LOG(RPDER(-1)))	-0.333322***	0.079415	-4.197223
<i>Variance Equation</i>			
C	0.00085***	5.14E-05	16.51342
RESID(-1) ²	0.32432***	0.093182	3.480555
R-squared	0.216069	Mean dependent var	-0.001123
Adjusted R-squared	0.206019	S.D. dependent var	0.041769
S.E. of regression	0.037219	Akaike info criterion	0.041769
Sum squared residuals	0.324149	Schwarz criterion	-3.936061
Log likelihood	472.3913	Hannan-Quinn criter.	-3.912542
F-statistic	21.49857	Durbin-Watson stat	2.464399
Prob(F-statistic)	0.00		

***significant at 1%

D(LOG(RPDER(-1))) - logarithmic value of the first difference of duck egg price lagged by one month;

RESID(-1)² - squared residual lagged by one month

Table 3: Results of supply response estimation for duck egg, Philippines, 1990-2009.

Variables	Coefficient	Std. Error	t-Statistic
Constant	-0.1310*	0.0648	-1.8228
Trend	-0.0002	0.0005	-0.1452
Quarter 2	0.1654**	0.0586	1.9249
Quarter 3	-0.0040	0.0294	-0.3461
Quarter 4	0.2497**	0.0529	3.7679
Lagged expected real price of duck egg (Δ)	0.9522*	0.3776	0.9285
Expected price variance of duck egg	1.2930	1.4786	0.9648
Lagged real price of pork (Δ)	0.4742	0.4813	0.9582
Lagged real price of beef (Δ)	0.2297	0.4689	0.1946
Lagged real price of diesel (Δ)	0.1889	0.1328	0.6514
Lagged real price of yellow corn (Δ)	0.2214	0.2516	1.5345
Error-correction (Δ)	-0.8895**	0.1512	-4.7392
Lagged duck egg production ($\Delta t - 1$)	-0.6630**	0.0692	-10.0249
R-squared	0.9599	-2.36	
Durbin-Watson	1.6671	-2.36	
N	77	-2.36	

*significant at 5%; **significant at 1%; Δ - means change or first difference